8.0 IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

This section presents the initial components of the Feasibility Study (FS) for the City of Moses Lake Maintenance Facility. It provides the identification and screening of remediation technologies where candidate technologies are screened on a site-specific basis to obtain a list of technologies feasible for use in assembling remediation alternatives.

These components are presented in the following sections.

8.1 Identification and Screening of Technologies

WAC 173-340-350(8)(b) affords the person conducting the FS the opportunity to screen alternatives or components from detailed evaluation. This section identifies and screens technologies or components that may be included as part of the remediation alternatives for the Site. A comprehensive list of technologies and process options that are potentially applicable to this Site is developed to cover all the applicable general response actions. The list of technologies is then screened to develop a refined list of potentially feasible technologies that can be used to develop remediation alternatives for the Site. The remediation alternatives/technologies are screened based on a preliminary analysis that first identifies those alternatives/technologies that clearly do not meet the threshold requirements identified in WAC 173-340-360(2)(a), which include:

- Protection of human health and the environment,
- Compliance with cleanup standards,
- Compliance with applicable state and federal laws, and
- Providing for compliance monitoring.

WAC 173-340-360(2)(b) requires that when selecting from cleanup actions that meet the minimum requirements, the action shall use permanent solutions to the maximum extent practicable and provide for a reasonable restoration time frame. The procedures for determining whether a cleanup action provides a reasonable restoration time frame are provided in WAC 173-340-360(4).

To determine if a cleanup action uses permanent solutions to the maximum extent practicable, the cleanup action is to be evaluated with respect to the following hierarchy of criteria presented in WAC 173-340-360(3)(f) as:

> **Protectiveness** - Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.
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> **Permanence** - The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction of elimination of hazardous substances releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.
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> **Cost** - The cost to implement the alternative, including the cost of construction, the net present value of any long-term costs, and agency oversight costs that are cost recoverable.

Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs, and the cost of maintaining institutional controls. Cost estimates for treatment technologies shall describe pretreatment, analytical, labor, and waste management costs. The design life of the cleanup action shall be estimated and the cost of replacement or repair of major elements shall be included in the cost estimate.

Effectiveness over the long term - Long-term effectiveness includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. The following types of cleanup action components may be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness: reuse or recycling; destruction or detoxification; immobilization or solidification; on-site or off-site disposal in an engineered, lined and monitored facility; on-site isolation or containment with attendant engineering controls; and institutional controls and monitoring.

Management of short-term risks - The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.

Technical and administrative implementability - Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary off-site facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions.

Consideration of public concerns - Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

Various technologies may only serve as one aspect or component of a cleanup action and may not solely meet all of the threshold requirements. However, the hierarchy of criteria identified above can be used for purposes of screening technologies (as a components of a cleanup action) from detailed analysis in a qualitative manner with the exception of consideration of public concern.

The technologies and process options are screened against the criteria hierarchy listed above using the "fatal flaw" approach. This approach ranks the criteria in order as listed above. Once a technology is rejected based on protectiveness, it is not further evaluated based on subsequent criteria. Similarly, if a technology is protective, but not permanent, the technology is rejected and evaluation of subsequent criteria is not undertaken. This approach streamlines the evaluation of technologies while maintaining the MTCA screening methodology.

Evaluation and screening of technologies are performed in a single step. The key criterion in selecting the screening level (technology class, individual technology, or process option) is whether there is a significant difference between the technologies or process options when evaluated against the screening criteria. Technologies and process options that are judged to have significant differences are screened separately, and the retained technologies or process options will be developed into separate remediation alternatives to allow full evaluation and comparison.

Process options that are screened together (i.e., not evaluated separately) and retained for any given technology are considered equally suitable (at the screening level of evaluation). Selection of representative process options is performed during the development of alternatives, so that best engineering judgment may be used to select and combine appropriate technologies and process options into cohesive, integrated remediation alternatives.

The potentially applicable remediation technologies considered for the Site are presented in Table 8-1 at the end of this section. The technology screening evaluations are also summarized in the table. Brief descriptions of the listed technologies and discussions of the screening evaluations are provided below. Technologies retained through this screening process are then incorporated into remediation alternatives in Section 9.

8.1.1 General Response Actions

General response actions are broad categories of remedial actions that can be combined to meet remedial goals at a site. The following general response actions are generally applicable to most sites, including the Moses Lake Maintenance Facility Site:

- No action
- Institutional controls (including monitoring)
- Containment
- Treatment (ex-situ or in-situ)
- Disposal (on-site or off-site)
- Removal.

Except for "no action," each of these response actions represents a category of technologies. The applicable technologies will vary depending on the media (e.g., soil or groundwater) and COCs (e.g., organic compounds or metals). The discussion of technologies is organized below by general response actions for groundwater and soil (the applicable media).

8.1.2 Institutional Controls And Monitoring

Institutional controls are legal and physical restrictions placed on a site to prevent exposure to COCs. Risk is mitigated by institutional controls to the extent that they prevent exposure to affected media including areas where elevated concentrations are present. However, institutional controls do not prevent off-site transport of constituents. Institutional controls include any maintenance required for ongoing effectiveness. Institutional controls are effective within their limitations, are easily implemented, and are low in cost. Institutional controls are typically included in any remedy where COCs will remain after completion of remediation. Institutional controls with monitoring alone are not protective of human health and the environment and do not meet the MTCA cleanup standard for this site, and therefore do not meet the threshold requirements of WAC 173-340-360 2(a)(i) through (iv).

Site Access Restrictions. Access restrictions involve preventing access by unauthorized persons. Fencing, combined with warning signs, is the most common means of restricting access. Security patrols are sometimes included for high-risk areas, but would not be warranted for this site. Fencing provides a physical barrier to site access. Warning signs discourage trespass by warning potential intruders of the hazards of entering the area. The maintenance facility is currently entirely fenced and access is limited to City personnel or personnel under the direction of the City. Fencing and warning signs are retained for further consideration.

Land Use Restrictions. Land use restrictions are legal controls such as deed restrictions and zoning that limit development or activities at a site. Deed restrictions are notices of land use restrictions that accompany the deed to the property in a manner that is legally binding and must be transferred to all subsequent owners of the property. The restrictions would include a description of the site and reasons for the limits on future activity. Such restrictions would prevent activities or development that could cause direct exposure to COCs, or that would compromise the integrity of the remedy. For example, deed restrictions would prohibit site development that could impair the effectiveness of a cap remedy. Land use restrictions are retained for further consideration.

Monitoring. Site monitoring may be a required component of any site remedy. Short-term monitoring is conducted to ensure that potential risks to human health and the environment are controlled while a site remedy is being implemented. Long-term monitoring is conducted to measure the effectiveness of the remedy and thereby ensure that the remedy continues to be protective of human health and the environment. Long-term monitoring would include periodic site inspections as necessary to determine maintenance needs (e.g., for fencing or a cap). A monitoring plan will be developed for the selected remedial action. The type of monitoring performed will depend on the nature of the remedy.

8.1.3 Containment

In-situ containment is a general response action used to prevent exposure to material affected by COCs that are left in place, and to control migration of constituents. Containment technologies are identified and screened in this section.

Capping.
Capping is a proven, effective technology for providing reliable long-term containment and preventing or minimizing off-site migration of constituents. Capping minimizes risk by preventing direct contact with hazardous substances in affected soil, and preventing off-site migration of constituents in surface water or airborne dust. Where infiltration through hazardous substances or affected soil is a concern, a low-permeability cap design is used to minimize the potential for constituent migration into groundwater by minimizing infiltration of precipitation.

Caps may be constructed of a variety of natural materials (i.e., clay, sand, and other soils), synthetic liners, geotextiles, other geomembranes, and other synthetic materials (e.g., asphalt or concrete). They may consist of a single layer or be a composite of several layers. Caps provide containment in three primary ways:

- A cap serves as a physical barrier to prevent humans, other animals, and vegetation from coming in contact with materials affected by COCs.
- A cap prevents erosion of soil by surface water and wind, thereby preventing off-site transport of COCs via surface water or wind.
- A low-permeability cap minimizes infiltration of surface water, decreasing the potential for transport of COCs in the soil to groundwater.

Caps can be designed to be compatible with many potential future site uses. Land use restrictions and other institutional controls are typically employed along with capping to prevent future site activities that could violate the integrity of the cap (e.g., excavation or support pilings for buildings). Long-term maintenance and monitoring are required.

Capping is readily implemented using standard design and construction techniques. It is relatively low cost, and thus highly cost-effective (i.e., high incremental protection relative to remediation cost). Capping technology is retained for further consideration.

Dust Control.
Dust control incorporates any measures to prevent wind dispersion of soil affected by COCs. Several approaches to dust control are available. Water is the most common method of short-term dust control. For long-term dust control, vegetation can be planted to hold the soil together and reduce wind velocity at the ground surface. Migration of site constituents via dust is not a problem at this site. However, excavation of the contaminated soil could generate dust from affected soil; therefore, dust controls are retained for possible use in conjunction with excavation.

Surface Water Controls.
Surface water management involves controlling surface water run-on and run-off at a site. The purpose of these controls is to minimize erosion that can entrain exposed soil affected by COCs, and expose underlying affected materials. Surface water controls by themselves are not generally effective as a permanent remedy. These controls may be used as short-term measures (e.g., during excavation), or as long-term measures (e.g., as part of capping). Surface water controls are proven technology, effective, easily implemented and inexpensive. They are therefore retained for use in conjunction with other remediation technologies.

8.1.4 Removal

Removal is a general response action for media affected by COCs prior to ex-situ treatment or disposal (on-site or off-site). Removal can be complete (i.e., all portions of soil with constituents above remediation goals), or partial (i.e., the highest concentrations of a constituent of concern). Removal by itself is not a complete remedial action, but must be combined with subsequent treatment and/or disposal of the removed media.

Excavation.
Removal of affected soil from the contaminated areas is technically feasible. Equipment that would be considered includes backhoes, loaders, bulldozers, clamshells, and draglines. The choice of equipment is typically made by the excavation contractor and is not normally part of design.

Excavation of affected soil would be necessary to allow ex-situ treatment or off-site disposal. Therefore, excavation is retained for use in conjunction with appropriate treatment or disposal technologies.

8.1.5 Ex-Situ Treatment

There are numerous technologies available for ex-situ soil treatment. The soils are treated with the intent of reducing the toxicity, mobility, or volume of material. However, all require the removal of affected soil and vary in the degree on implementability.

This section considers a wide range of technologies for ex-situ soil and waste treatment following excavation. A treatability study would be necessary to determine the appropriate treatment method, should excavation and treatment of contaminated material be selected as the recommended remediation action. Ex-situ soil treatment technologies are therefore identified and screened for this eventuality.

Treatment is intended to reduce the toxicity, mobility, or volume of material affected by COCs. Many treatment technologies convert COCs to less toxic forms. Destruction or degradation of organic compounds is possible (e.g., oxidation to carbon dioxide and water) although not always feasible or cost-effective. However, metals cannot be destroyed by treatment. Metal toxicity can be reduced via chemical conversion to a less toxic compound of the metal, and metals can be immobilized by fixation (stabilization).

Reuse/Recycling. The reuse and recycling of impacted soil can be accomplished if impacted soils are excavated and transported to a landfill. The impacted soil may be used as landfill cap material, although no other waste materials have been identified at this site with the potential for reuse or recycling. The reuse and recycling of impacted soils as landfill cover in general provides an effective permanent solution that is protective of human health and the environment and is easily implementable. This technology is therefore retained for use in conjunction with disposal technologies.

Dry Soil Sieving. Dry soil sieving is an ex-situ physical separation process that is performed without the addition of water. Soil is passed through one or more screens and separated into various size fractions. The concept behind remediation using this technology is that the concentrations of COCs in soil particles often increase with decreasing particle size. In addition, large-mesh screens (e.g., a grizzly) are commonly used to remove debris and other large objects from waste and affected soil to facilitate handling. Although not as effective as physical soil washing, it is easy to implement and much less costly (generally a few dollars per ton of soil treated). When applicable, it is highly cost-effective because of reduction in disposal costs. Therefore, this technology is retained for possible use in the design phase for separating clean soil, debris, and affected soil in conjunction with excavation if an excavation alternative is selected.

Physical Soil Washing (Aqueous Physical Separation). The term "soil washing" has been used to describe a variety of treatment processes. As used here, physical soil washing refers to soil washing for physical separation; "chemical extraction" is used to refer to processes using aqueous and non-aqueous solvents for extraction of COCs. Physical soil washing is applicable to soil where the COCs are concentrated in a particular size fraction. In practice, the majority of COCs in soils are often associated with the silt and clay soil fractions (collectively called the fines), with coarser soil (sand and gravel) being relatively clean.

The effectiveness of physical soil washing is highly variable, depending on the COCs and site-specific conditions. In addition, treatment of the wash water is necessary prior to discharge, and the fines must be dewatered for landfill disposal. Physical soil washing is also a relatively complex process and requires use of specialized contractors. For the most part the limited solubility of petroleum products particularly the heavier end oils eliminates the use of water alone and requires the use of surfactants. Soil washing systems for site remediation are innovative and currently in various stages of development and implementation. Physical soil washing would not provide proven, reliable treatment for this site, and would be difficult to implement. This technology is therefore not retained.

Chemical Extraction. Chemical extraction is a generic term for treatment processes where a liquid solvent is used to extract COCs from waste or affected soil. The spent solvent must then be treated or recovered and recycled. The terms "soil washing" and "solvent extraction" are sometimes used for processes included in this treatment category. Aqueous soil washing is included in this category when the purpose of the treatment is removal of COCs from the soil, rather than separation of soil into affected and clean fractions as in physical soil washing. Other solvents and reagents that can be used include surfactants, liquid carbon dioxide, and triethylamine (TEA) for organic compounds; petroleum solvents for oil recovery; and acids or complexing agents for metals.

A number of chemical extraction processes, including extractive soil washing, have been attempted at bench and pilot project scales with varying degrees of success. The effectiveness of chemical extraction is highly dependent on the COCs and site-specific waste characteristics. Published data show large variations in effectiveness between sites. Chemical extraction at this site would have all of the problems cited for physical soil washing, but to a greater degree. It is less proven technology, more complex and difficult to implement, and could result in a disproportionate cost. This technology is therefore not retained.

Fixation (Chemical Stabilization). Fixation, also called chemical stabilization or simply stabilization, involves mixing soil affected by COCs with binding agents to form a solid matrix that immobilizes the COCs, and thereby reduces constituent mobility (leachability) and associated risk. Fixation typically uses pozzolanic agents, such as cement, fly ash, and lime. Selecting stabilization as a remediation technique requires laboratory testing to verify the fixing agent is effective. The presence of high concentrations of adsorbed oil on soil particles being stabilized may interfere with the process and result in structurally poor soils. Proprietary additives are available that are claimed to improve immobilization and stability. Fixation is a common, established technology for treatment of wastes and soils affected by heavy metals. Metals are typically immobilized by both chemical bonding and physical entrapment; organic compounds are immobilized only by entrapment. Fixation is a proven technology for immobilization of a variety of constituents, and is not difficult to implement on-site or off-site. This technology is therefore retained for possible use, but only to the extent required to meet regulatory requirements for treatment prior to off-site disposal.

Biological Treatment. Biological treatment is a class of technologies commonly applied for destruction of organic COCs. Biological treatment encompasses a number of treatment methodologies and can be performed ex-situ and in-situ, with varying effectiveness, and may be accomplished by aerobic oxidation or anaerobic reduction processes.

Whether considering ex-situ or in-situ methods biological treatment is based on the principle that a number of microorganisms exist naturally in most soils or can be introduced. These organisms which include many species of bacteria and fungi can use organic chemicals as an energy supply and results in the degradation of the chemicals. Many factors impact the effectiveness of the biological treatment of soils including moisture content, soil porosity, availability of oxygen, pH, toxicity of chemical present in the soil to microbes, and temperature to identify a few. The balance of these and other factors determines the effectiveness of biological treatment.

Biological treatment can have high effectiveness for some constituents, such as lighter petroleum hydrocarbons, and poor effectiveness for many others, such as PAHs and heavy oils. Biological treatment will not destroy metals or remove them from soil. It is usually not suitable for solids wastes with high concentrations of COCs. The difficulty of implementation can vary wide, depending on the matrix and the COCs. When effective, biological treatment is usually inexpensive relatively to other organic destruction technologies. Because of its limitations and lack of proven effectiveness in treating the heavier organic COCs (motor oil range petroleum hydrocarbons) associated with this Site, biological treatment technologies are not retained.

Chemical Oxidation/Reduction. Chemical oxidation-reduction reactions can be used to reduce toxicity or to transform a substance to one more easily handled. Oxidizing or reducing reagents (as appropriate) are added to cause or promote the desired reaction. For example, oxidizing agents can be used to destroy or detoxify organic compounds. However, chemical oxidation/ reduction of solid waste or affected soil is unproven technology as many factors impact the effectiveness of the chemical treatment of soils including moisture content, soil porosity, pH, buffering capacity of the soil with respect to the reagent used, and temperature to identify a few. The balance of these and other factors determines the effectiveness of chemical treatment, which can be difficult to control. Monitoring the reaction for control purposes can also prove difficult. This technology is therefore not retained.

Thermal Treatment. Thermal treatment technologies are primarily designed for destruction of organic COCs. Thermal desorption is a typical thermal treatment technology, where COCs are volatilized (put in the vapor phase) for subsequent thermal destruction. Thermal treatment does not destroy or immobilize metals; thus the ash from thermal treatment may require fixation before landfill disposal.

On-site thermal treatment and off-site thermal treatment are both technically and administratively achievable for this Site, and are both are retained for further consideration. On-site thermal treatment would minimize or eliminate the requirements for off-site transportation and have less impacts on traffic. However, on-site thermal treatment is generally more difficult to implement from both a technical and administrative standpoint, due to stack testing, air permitting requirements and resistance often encountered from the public.

8.1.6 In-Situ Treatment

This section considers technologies that treat COCs in place. As with ex-situ treatment, the purpose of in-situ treatment is to reduce the toxicity, mobility or volume of COCs. The same classes of treatment that are available for ex-situ soil treatment are generally available for in-situ treatment. However, the treatment conditions are very different. There are a number of in-situ treatment technologies that could be considered, including:

- Biological treatment (soil/groundwater).
- Chemical oxidation/reduction (soil/groundwater).
- In-situ fixation (e.g., grout injection or deep soil mixing).

When feasible, the key advantage to in-situ treatment is that excavation of the soil is avoided. However, the difficult aspects with these three technologies were presented in Section 8.1.5. The key disadvantage to in-situ treatment is that the treatment process cannot be controlled nearly as well as the same treatment in a reactor or other process equipment following excavation. This decrease in control results from a combination of greater difficulties in achieving desired process conditions, and the inherent heterogeneity of the subsurface. Therefore, an in-situ treatment process is generally less effective at achieving treatment objectives and less reliable in achieving uniform treatment than the corresponding ex-situ treatment process. Treatment effectiveness is also often difficult to verify, therefore, no in-situ treatment technologies are retained. For this site, treatment would be better performed ex-situ, if treatment is selected.

8.1.7 Disposal

Disposal is a general response action for final disposition of excavated waste and affected soil, or waste generated by treatment processes. Landfill disposal relocates COCs from one place to another for long-term containment; it does not use treatment to destroy or detoxify COCs. However, if needed, treatment can be used prior to disposal. The options for disposal following excavation are an on-site constructed landfill, and off-site landfill disposal (including any treatment under land disposal regulations).

On-Site Disposal (Consolidation of Impacted Soil). On-site consolidation of impacted soil requires excavation of an area large enough to contain the contaminated soil, containment (i.e., liner), and capping. Long-term monitoring would also be required.

At this Site, groundwater is not impacted (except at MW-11), therefore reducing infiltration would be more effective than having a liner below the impacted soils. In-place containment would provide protection against direct contact or migration of COCs. In-place containment would also avoid the added step of excavating. Capping with groundwater monitoring would provide the same level of protection of human health and the environment, but would be much easier to implement. Off-site disposal would be a better option in the event an excavation alternative was selected. On-site disposal (consolidation of impacted soil) is therefore not retained.

Off-Site Disposal. Commercial or municipal landfills could be used for disposal of waste or affected soil excavated from the contaminated areas. The appropriate landfill would depend on the nature of the material for disposal. Municipal landfills are allowed to accept waste that is not classified as hazardous under federal (RCRA) regulations or as dangerous under Washington State regulations. The Rabanco Landfill in Roosevelt, Washington and the Waste Management Graham Road Landfill in Medical Lake, Washington have been identified as potential landfill locations. The cost of off-site disposal could potentially be decreased if this technology were combined with appropriate ex-situ treatment technology. Off-site disposal is retained for further consideration.